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DOI:

[10.1080/01402390.2019.1627521](https://doi.org/10.1080/01402390.2019.1627521)

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Citation for published version (APA):

Williams, H. W. (2019). Asymmetric arms control and strategic stability: Scenarios for limiting hypersonic glide vehicles. *The Journal of Strategic Studies*, 42(6), 789-813. <https://doi.org/10.1080/01402390.2019.1627521>

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Journal:	Journal of Strategic Studies
Manuscript ID	Draft
Manuscript Type:	Original Article
Keywords:	Arms control, Strategic stability, Hypersonic, Emerging technology

**Asymmetric Arms Control and Strategic Stability:
Scenarios for Limiting Hypersonic Glide Vehicles¹**

Can arms control incorporate emerging technology? Other articles in this special issue identify potential risks emerging technologies pose to stability and how they are intertwined with international politics. This article looks ahead to explore how arms control might reduce those risks, but in order to do so we must update concepts of both arms control and strategic stability. Building on Thomas Schelling and Morton Halperin’s seminal study into the relationship between strategic stability and arms control, this article offers an original framework- asymmetric arms control- for incorporating new technologies, which is then used to identify six scenarios for arms control of hypersonic glide vehicles (HGVs). It concludes that arms control can potentially reduce the risks to strategic stability associated with emerging technologies by incorporating dynamism into arms control design. Ultimately, asymmetric arms control can best contribute to strategic stability by crossing domains and reflecting the cross-domain nature of international conflict, and the framework has potential application to emerging technologies beyond HGVs.

Keywords: Arms control, strategic stability, hypersonic glide vehicles, emerging technology

Word Count: 8,867

¹ I am grateful to James Acton, Francis Gavin, Brendan Rittenhouse Green, Michael Horowitz, Vince Manzo, Rupal Mehta, Amelia Morgan, Brad Roberts, Caitlin Talmadge, and the anonymous reviewer for their feedback on this article. I am also particularly grateful to the Carnegie Corporation of New York for sponsoring the Project on Strategic Stability Evaluation (POSSE), which provided the opportunity to develop and socialize these ideas, and to POSSE participants for their suggestions.

Introduction

Can arms control incorporate emerging technology? Relations between the United States and Russia are more dangerous than at any point since the end of the Cold War, and emerging technologies, such as hypersonic glide vehicles (HGVs), will exacerbate risks of misperception, military competition, and inadvertent escalation.² Other articles in this special issue highlight the potential threats emerging technologies pose to international politics and stability. This article offers an original framework³ for examining how arms control might evolve to incorporate these emerging technologies, asymmetric arms control, defined as cooperative measures of self-restraint in which states make non-like-for-like exchanges, either quantitatively or qualitatively. Arms control was, in the past, seen as a key element of promoting strategic stability, international cooperation, and peace. There have been, to be sure, critics of this view. A new challenge, however, has emerged that is of concern for both advocates and sceptics of arms control – how to manage the emergence of new and varied technologies that threaten peace and stability, but which are hard to define as part of one domain.

Strategic stability offers a useful lens for addressing these conceptual, technological, and political challenges. During the Cold War, Thomas Schelling and Morton Halperin⁴, along with others, argued that one objective of arms control was to strengthen strategic stability, defined as arms race stability and crisis stability.⁵ Arms control was about the management of weapons rather than disarmament⁶ and provided

² See, for example, Aaron Miles, 'The dynamics of strategic stability and instability', *Contemporary Security Policy*, 35/5 (2106), pp. 423-437.

³ Lieber and Press highlight the need to challenge existing models of arms control, whereby, 'In the past, many arms control advocates believed that arms cuts reduced the incentives for disarming strikes; whether right or wrong in the past, that assumption is increasingly dubious as a recipe for deterrence stability today.'³ Keir Lieber and Daryl G. Press, 'The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence', *International Security*, 41/4 (2017), pp. 9-49.

⁴ Thomas C. Schelling and Morton H. Halperin, *Strategy and Arms Control* (New York: The Twentieth Century Fund, 1961).

⁵ For a particularly useful discussion on the evolution of the concept of arms control in relation to disarmament, along with controversy around the term 'strategic stability', see Benjamin Wilson, 'Insiders and Outsiders: Nuclear Arms Control Experts in Cold War America', Dissertation submitted to the Massachusetts Institute of Technology, September 2014.

⁶ See, for example, Jeffrey D. McCaulsland, 'Arms control and the Dayton accords', *European Security*, 6/2 (1997), pp. 18-27: "Arms control" refers to agreements between two or more states to limit or reduce certain categories of weapons or military operations in order to diminish the possibility of conflict.... "Disarmament" is normally imposed by a state or a group of states at the conclusion of war.... This distinction is important because, while an arms control regime is maintained by a harmony of interests among the participants, disarmament requires external pressure to insure implementation

transparency that could reduce risks of misperceptions during a dangerous crisis. This approach linking arms control and strategic stability has been largely ignored in recent scholarship, however, which focuses on three debates within arms control. First, critics of the strategic stability approach argue that historically arms control has been a technical counting exercise, and it needs to adopt a more holistic and political approach.⁷ Second, a select group of scholars have engaged with questions about the formality of arms control, and whether or not arms can contribute to international security by becoming more flexible and moving away from legally-binding treaties.⁸ And finally, policy circles offer numerous recommendations for future arms control agreements, but few of them examine the underlying political and stability factors that shape arms control.

This article begins by building on Schelling and Halperin's classic thesis linking arms control and strategic stability, and redefines the underlying principles of arms control as crisis stability, arms race stability, *and* an arms control norm. Second, the article identifies three new challenges to strategic stability which thus far have eluded arms control efforts- different perceptions of strategic stability, the increasingly asymmetric nature of stability, and the potential of emerging technology to upset stability, specifically HGVs.⁹ Finally, the article outlines the asymmetric arms control typology and includes six scenarios for HGV arms control as demonstrative examples. This study offers an original contribution to scholarship into the impact of emerging technology on international politics. It highlights the need for dynamism in any arms control framework to promote strategic stability in a rapidly changing era of geopolitical and technological uncertainty. Indeed, given the increasingly cross-

and compliance.... It is also critical to recall that arms control is a 'method or means' to achieve the "objective" of improve security. But arms control is not an objective by itself.' pp. 18-19.

⁷ Nancy Gallagher, 'Re-thinking the unthinkable: Arms control in the twenty-first century', *Nonproliferation Review*, 22/3-4 (2015), pp. 469-498; and Neil Cooper and David Mutimer, 'Arms control in the 21st Century: Controlling the Means of Violence', *Contemporary Security Policy*, 32/1 (2011), pp. 3-19.

⁸ Sarah Kreps, 'The Institutional Design of Arms Control Agreements', *Foreign Policy Analysis* (2016), pp. 1-21; and Mary Ellen O'Connell, '21st Century Arms Control Challenges: Drones, Cyber Weapons, Killer Robots and WMDs', *Washington University Global Studies Law Review*, 13/3 (2015).

⁹ On related themes, see Horowitz, Michael C., 'When Speed Kills: Autonomous Weapons Systems, Deterrence, and Stability', *Journal of Strategic Studies* (2019).

domain nature of deterrence¹⁰ and asymmetries in nuclear, conventional, cyber, and other capabilities, arms control, too, must cross domains and explore asymmetries.

Revisiting *Strategy and Arms Control*

In their seminal 1960's text, *Strategy and Arms Control*, Schelling and Halperin link arms control to strategic stability as a means of managing the arms race and avoiding limited or accidental war. From this perspective, arms control can be defined as the management of weapons, rather than their elimination. Schelling and Halperin's definition from the Cold War resonates today and is worth quoting at length:

[A]ll the forms of military cooperation between potential enemies in the interest of reducing the likelihood of war, its scope and violence if it occurs, and the political and economic costs of being prepared for it. The essential feature of arms control is the recognition of the common interest, of the possibility of reciprocation and cooperation even between potential enemies with respect to their military establishments.¹¹

This approach emphasizes that arms control is a tool for achieving strategic aims through cooperative restraint rather than military competition. For Schelling and Halperin, the objectives of arms control include strengthening strategic stability, reducing the incentives for conflict, reducing the damage if conflict occurs, and economic savings. Focusing on the first objective, arms control can strengthen strategic stability by reducing the risks of arms races and crises, and by promoting an arms control norm. To better understand if arms control can strengthen strategic stability in an era of geopolitical and technological change, it is worth revisiting these traits of strategic stability.

Looking to arms race stability, states often pursue costly new military technologies due to uncertainty and, 'a constant fear on either side that the other has developed a dominant position, or will do so, or will fear the first to do so, with the resulting danger of premeditated or pre-emptive attack.'¹² Other articles in this special issue, for example, discuss the potential for artificial intelligence to increase uncertainty,

¹⁰ See, for example, Austin Long, 'Deterrence: The State of the Field', *International Law and Politics*, 47 (2015), pp. 357-377; and Dima Adamsky, 'Cross-Domain Coercion: The Current Russian Art of Strategy', *IFRI Proliferation Paper*, 54 (2015).

¹¹ Schelling and Halperin, p. 2.

¹² *Ibid.*, p. 37.

leading to a 'scale-up' in order to offset the offense-defense balance.¹³ This competition can be further driven by lack of information about an adversary's military development and as a result exaggerate capabilities, such as the 'missile gap'. Arms control can contribute to arms race stability by placing reciprocal limits on capabilities, increasing transparency into an adversary's actual capabilities and force posture, and reducing the likelihood of success in the event of military adventurism, according to Schelling and Halperin.

With regards to crisis stability, arms control reduces incentives for pre-emptive and premeditated attack because it can 'alter the character of the weapons themselves'¹⁴, 'reduce the general expectation of war...reduce the urgency to pre-empt'¹⁵, and 'reduce the likelihood that an attacker would achieve *surprise*.'¹⁶ Arms control offered a means of living with uncertainty about an adversary's intentions not only by reducing capabilities, but also by increasing transparency and reducing misinformation.¹⁷ To be clear, this is not intended to inflate the influence of arms control on broader geopolitics, but rather, borrowing from Trachtenberg, to 'influence the process' as much as possible away from misperception and escalation and towards transparency and predictability.¹⁸ Caitlin Talmadge reinforces this point, whereby, 'although technology could directly generate some future inadvertent escalation risk, the more likely role for technology is as an enabler of escalatory policies states want to undertake for other strategic and political reasons.'¹⁹ For Schelling and Halperin, arms control had the potential to mitigate that 'enabling' role.

Schelling and Halperin do not refer to an arms control norm, but do refer to 'traffic rules'²⁰ or general practices of restraint, which I include here as an objective of arms control in contributing to strategic stability. Legally-binding arms control agreements are a widely practiced behavior to promote cooperation over competition in

¹³ 'The Scaling of the Offense-Defense Balance, with Implications for Artificial Intelligence', this issue.

¹⁴ Ibid., p. 10

¹⁵ Ibid., p. 11.

¹⁶ Ibid., p. 12, italics in original.

¹⁷ Ibid., p. 13.

¹⁸ Marc Trachtenberg, 'The Past and Future of Arms Control', *Daedalus*, 120/1 (1991).

¹⁹ Caitlin Talmadge, 'Emerging Technology and Intra-War Escalation Risks: Evidence from the Cold War and Implications for Today', *Journal of Strategic Studies* (2019).

²⁰ According to Schelling and Halperin, abstaining from unilateral military action or even limited war itself are a type of arms control.

international security to the point of being a norm or ‘rules of the road’.²¹ Indeed, nearly every member of the United Nations is party to at least one arms control agreement, whether it be the Nuclear Non-Proliferation Treaty or the Comprehensive Test Ban Treaty. Cooper and Mutimer define the true benefits from arms control as ‘controlling means of violence’, whereby the substance of agreements was not necessarily the most important part of arms control, but rather, ‘the extent to which its practices contribute to a transformatory politics that produces demilitarized communities where such control is no longer needed.’²² These agreements therefore serve both practical and symbolic functions of manifesting ‘particular ideas of how international relations should be managed.’²³

Even during the Cold War Schelling and Halperin’s arguments about arms control and strategic stability faced criticism, and some of their points have not held up well over time. For example, Brendan Green and Austin Long argue that the 1972 Strategic Arms Limitation Talks (SALT) Interim Agreement enabled the United States to engage in a *qualitative* arms race, although it was tied to quantitative parity with the Soviet Union.²⁴ But rather than discard this approach, linking arms control and strategic stability, we can instead examine new challenges to strategic stability and develop an updated concept of arms control accordingly.

New Challenges for Arms Control and Strategic Stability

In the Eye of the Beholder

The current era of geopolitical and technological uncertainty presents at least three new challenges to strategic stability. First, evolution of the post-Cold War environment, along with historical work into Cold War dynamics, revealed that strategic stability means different things to different states. Indeed, some states may not always value stability as much as others, if at all. Returning to contemporary U.S.-Russia strategic competition as an example, the 2018 U.S. *Nuclear Posture Review* (NPR) highlighted the increasing uncertainty in the strategic environment.

²¹ See, also, Harald Muller and Carmen Wunderlich (eds.), *Norm Dynamics in Multilateral Arms Control* (London: University of Georgia Press, 2013).

²² Cooper and Mutimer, p. 12.

²³ Andrew Butfoy, ‘The evolving framework of arms control’, *Australian Journal of International Affairs*, 48:1 (1994), pp. 37-51.

²⁴ Brendan R. Green and Austin Long, ‘The MAD Who Wasn’t There: Soviet Reactions to the Late Cold War Nuclear Balance’, *Security Studies*, 26/4 (2017), pp. 606-641.

Historically the United States was tied to a definition of strategic stability as 'survivable second strike', but the NPR offered a new definition, which included non-nuclear capabilities that present a threat to nuclear systems.²⁵ This definition continues to lean towards the importance of capabilities in the strategic balance, but has expanded beyond nuclear forces to consider space, cyber, and other new technologies as part of the strategic equation. Additionally, the NPR acknowledged that arms control can play a role in promoting strategic stability, albeit options are currently limited, such as force limitations and risk reduction.²⁶

Russia, however, takes a more 'integrative'²⁷ and 'holistic'²⁸ approach to strategic stability to include non-nuclear capabilities, information operations, and broader political factors. This approach is decidedly asymmetric to play to Russia's advantages. In his translation of Russian strategic experts Chekinov and Bogdanov, Dmitry Adamsky defined asymmetry as, 'of a systemic and complex nature and incorporates (sic) political, diplomatic, informational, economical, military and other efforts.'²⁹ Russia's current reliance on nuclear weapons largely stemmed from the breakdown of its conventional forces with the end of the Cold War and economic collapse in the 1990's. Its 2000 Military Doctrine increased reliance on nuclear weapons, but as a 'temporary solution' while it worked to rebuild its conventional forces.³⁰ Kristen ven Bruusgaard described the concept as 'strategic deterrence', which:

...is conceived much more broadly than the traditional Western concept of deterrence. It is not entirely defensive: it contains offensive and defensive, nuclear, non-nuclear and non-military deterrent tools. These are to be used in times of peace and war- making the concept resemble, to Western eyes, a

²⁵ Heather Williams, 'Strategic Stability, Uncertainty and the Future of Arms Control', *Survival*, 60/2 (2018), pp. 45-54.

²⁶ *U.S. Nuclear Posture Review*, p. 72-73.

²⁷ Nikolai Sokov, 'Russian Perspectives on Nuclear Disarmament and Post-Nuclear World', in Nik Hynek and Michal Smetana (eds.), *Global Nuclear Disarmament: Strategic, Political, and Regional Perspectives* (London: Routledge, 2016).

²⁸ Adamsky.

²⁹ *Ibid.*, p. 34.

³⁰ Sokov, p. 217. Current Russian nuclear doctrine states, 'The Russian Federation shall reserve the right to use nuclear weapons in response to the use of nuclear and other types of weapons of mass destruction against it and/or its allies, as well as in the event of aggression against the Russian Federation with the use of conventional weapons when the very existence of the state is in jeopardy.' *Military Doctrine of the Russian Federation*, December 2014

combined strategy of containment, deterrence and coercion- using all means available to deter or dominate conflict.³¹

Russia's approach incorporates elements of both soft and hard power, political as well as military aspects, such as what Adamsky referred to as the 'informational-psychological struggle.'³²

This analysis demonstrates that strategic stability is in the eye of the beholder. Therefore, whether or not states have an interest in arms control depends on their national interests and perception of strategic stability, which is much more complex than previous models of stability and arms control.

Quantitative and Qualitative Imbalances

A second challenge for strategic stability and arms control is the asymmetric nature of conflict, as mentioned above from the Russian perspective. Asymmetry is increasingly important in the present strategic environment, defined by its cross-domain nature, wherein deterrence requires, 'countering threats in one area (such as space or cyberspace) by relying on different types of capabilities (such as sea power or nuclear weapons, or even non-military tools, such as market access) where deterrence may be more effective.'³³ Emerging technologies allow additional opportunities for asymmetry across domains; Ben Garfinkel and Allan Dafoe introduce the concept of 'OD scaling' (offense-defense), whereby 'growth in investments will favor offense when investment levels are sufficiently low and favor defense when they are sufficiently high.'³⁴ And Erik Gartzke demonstrates the potential for asymmetries in technology to extend the duration and nature of conflicts.³⁵ Consideration of these differences in qualitative and quantitative scale of capabilities do not readily align with Cold War models of strategic stability and arms control. These imbalances are reflected not only in capabilities, but also in broader factors such as geography, because of some states' proximity to a perceived threat and

³¹ Kristin Ven Bruusgaard, 'Russian Strategic Deterrence', *Survival*, 58/4 (2016), p. 7.

³² Adamsky, p. 24. This is often mistranslated to equate to American and Western definitions of cyberwarfare, but it entails a variety of 'digital-cognitive factors' and the 'regulation of information (cyber) space in a much broader sense than the West.' p. 29.

³³ Long pp. 366-367.

³⁴ Ben Garfinkel and Allan Dafoe, 'How Does the Offense-Defense Balance Scale?' *Journal of Strategic Studies* (2019).

³⁵ Erik Gartzke, 'Blood Robots: How Remotely Piloted Vehicles and Related Technologies Affect the Politics of Violence', *Journal of Strategic Studies* (forthcoming).

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respective attitudes towards agreements and cooperation.³⁶ Strategic stability no longer rests solely in the nuclear realm, and states will operate in other domains where they have a perceived advantage. This presents a challenge for arms control that is based on like-for-like exchanges.

As Green and Long demonstrated, however, stability through arms control is not a purely quantitative exercise, but also qualitative. States could use arms control as an opportunity to make qualitative improvements. Or, conversely, some states are *negatively* affected in arms control more so than others, resulting in an imbalance or instability that could actually *increase* risks. If the 1972 SALT Interim Agreement had set parity in number of submarines, for example, this would have been felt asymmetrically by the United States and Soviet Union. The Soviet Union would have had to make significantly larger cuts to its nuclear forces than the United States and, in all likelihood, would not have signed the Agreement. To take a hypothetical example outside of the U.S.-Russia context, if the Netherlands joined the 2017 Treaty on the Prohibition of Nuclear Weapons (TPNW), this would have an asymmetric impact compared to a state such as Mexico joining. As a NATO member and base for dual-capable aircraft, the Netherlands would have to reject NATO's nuclear mission, cease any activities that could be construed as 'assistance' to nuclear deterrence postures, and ostensibly withdraw from NATO in its current form in order to comply with the TPNW. Mexico, on the other hand, would not have to make any changes as it does not rely on nuclear deterrence.

Emerging Technology- Hypersonic Threats to Strategic Stability

And third, emerging technologies, such as HGVs, may inspire arms races or crises, undermining Schelling and Halperin's principles for strategic stability. Schelling and Halperin's observation on the impact of emerging technologies could be equally true today:

The present race seems unstable because of the uncertainty in technology and the danger of a decisive break-through. Uncertainty means that each side must be prepared to spend a great deal of money; it also means a constant fear on either side that the other has developed a dominant position, or will do so, or

³⁶ Thomas Bernauer and Dieter Ruloff (eds.), *The Politics of Positive Incentives in Arms Control* (Columbia, SC: University of South Carolina Press, 1999), p. 15.

will fear the first to do so, with the resulting danger of premeditated or pre-emptive attack.³⁷

These fears and uncertainties resonated in the 2018 U.S. NPR focus on the impact of emerging nuclear and non-nuclear technologies due to, ‘the potential for technological breakthroughs in the application of existing technologies, or the development of wholly new technologies, that change the nature of the threats we face and the capabilities required to address them effectively.’³⁸ Many of these emerging technologies also are dual-use in nature- either civilian and military or nuclear and conventional- as highlighted by Tristan Volpe’s study of how technologies such as additive manufacturing interplay with the security dilemma.³⁹

One such technology with the potential to change the nature of threats is HGVs, which launch a missile into the atmosphere, which then re-enters on a glidepath and can be steered to a target with a high degree of maneuverability in order to evade defenses. They are capable of speeds of Mach 5 or faster, can support heavy payloads, and eventually are intended to have inter-continental range.⁴⁰ Re-entry glide vehicles are not counted under any existing strategic arms control agreement and likely can carry both nuclear and conventional warheads. HGVs are discussed here not because they are the most threatening of emerging technologies, but rather to demonstrate the challenges these technologies potentially present to strategic stability and the increasing amount of uncertainty around their impact on arms races, crises, and international politics more generally.

In terms of arms race stability, the United States, Russia, and China are already competing in the development of HGV technology. In the 2002 NPR, the United States announced plans for advanced conventional weapons, the Conventional Prompt Global Strike (CPGS) system, to be part of a new strategic triad, along with defenses and military innovation.⁴¹ By the 2020’s, the United States is expected to have a ‘spearhead’ HGV force to conduct operations such as targeted strikes and evading

³⁷ Schelling and Halperin, p. 37.

³⁸ U.S. Department of Defense, *Nuclear Posture Review* (Washington, DC: 2018).

³⁹ Tristan Volpe, ‘Dual-Use Distinguishability: How 3D-Printing Shapes the Security Dilemma for Nuclear Programs,’ *Journal of Strategic Studies* (2019).

⁴⁰ *Ibid.*, p. 213.

⁴¹ *U.S. Nuclear Posture Review*.

anti-access/area-denial.⁴² Russia's hypersonic Project 4202 included a successful 2016 test and its new heavy ICBM, the Sarmat, is expected to carry the HGVs with up to 24 per missile.⁴³ China has conducted at least seven HGV tests to date, the most recent using a DF-21 ballistic missile with a range of 2,200 km although it is expected to eventually transition HGVs to longer-range ballistic missiles, such as the DF-31 that can reach 8,000km.⁴⁴ Competition in HGVs seems inevitable and all three states will feel obligated to continue in developing and deploying the technology rather than risk falling behind in a perceived 'HGV gap'.

With regards to the potential impact of HGVs on crisis stability, scholarship focuses on three risks. First, in a series of reports and articles, James Acton and other experts at the Carnegie Endowment for International Peace demonstrated the risks of 'entanglement', to include, 'dual-use delivery systems that can be armed with nuclear and non-nuclear warheads; the commingling of nuclear and non-nuclear forces and their support structures; and non-nuclear threats to nuclear weapons and their associated command, control, communication, and information (C3I) systems.'⁴⁵ This entanglement of nuclear and non-nuclear capabilities increases the risks of inadvertent or unintentional escalation. As argued by Acton elsewhere, HGVs also present a particularly unique risk of entanglement because of their dual-use nature, creating 'warhead ambiguity' and 'destination ambiguity' given their dual-use nature, maneuverability, and lack of transparency in targeting.⁴⁶

Second, HGVs and other advanced conventional weapons in high numbers may embolden states to believe they can conduct a disarming first strike. Lieber and Press recently argued that during the Cold War and through to the present day states have sought capabilities to achieve as much. They argue that emerging technologies will

⁴² Corentin Brustlein, 'Conventionalizing Deterrence? U.S. Prompt Strike Programs and Their Limits', *IFRI Proliferation Paper*, 52 (2015).

⁴³ Pavel Podvig, 'Summary of the Project 4202 development', *Russian strategic nuclear forces blog*, June 16, 2015.

⁴⁴ Joshua Pollack, 'Boost-glide Weapons and US-China Strategic Stability', *Nonproliferation Review*, 22/2 (2015) pp. 155-164.

⁴⁵ Alexey Arbatov, Vladimir Dvorkin, Petr Topychkanov, Tong Zhao, and Li Bin, *Russian and Chinese Perspectives on Non-Nuclear Weapons and Nuclear Risks*, Carnegie Endowment for International Peace (2017), p. 1.

⁴⁶ Acton.

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3 make nuclear arsenals less survivable⁴⁷ and echoed Cold War arguments, such as
4 those by Bernard Brodie, that despite technological improvements states would
5 always perceive, ‘considerable advantage in striking first, and it is up to us to see that
6 such an advantage is at least minimized for the opponent.’⁴⁸ Weapons such as HGVs
7 may give states the *perception* that they could conduct a disarming first strike against
8 an adversary’s nuclear forces.
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15 And finally, advances in conventional weapons technology occur in parallel with calls
16 for the United States and Russia to reduce reliance on nuclear weapons. While such a
17 change in posture is unlikely in the immediate future based on Washington and
18 Moscow’s doctrines, any future shift whereby states increase reliance on conventional
19 weapons will complicate strategic stability.⁴⁹ Some analysts suggest the best way to
20 strengthen strategic stability and reduce incentives for nuclear use is to reduce the
21 number of nuclear weapons⁵⁰; however, if this comes at the expense of increasing
22 reliance on conventional weapons, that may weaken stability and increase risks.
23 Again, these pressures would be heightened in a crisis scenario if states possessed
24 large HGV arsenals but fewer nuclear weapons by shifting the ‘burden of escalation’
25 onto an adversary in a ‘use-it-or-lose-it’ scenario.⁵¹ What these risks suggest is that
26 HGVs are potentially destabilizing in some situations, and competition may already
27 be a reality.
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39 *Dynamic Stability*

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41 Existing arms control models and concepts of strategic stability struggle to respond to
42 these changes. To better understand the changing nature of strategic stability, this
43 article draws on different disciplines that also use the concept of strategic stability,
44 namely mathematics and ecology. The application of mathematical models to
45 strategic stability in the arms control context is not new, given the contribution of
46 game theory. In a 1990 mathematical model of strategic stability, a group of Russian
47 mathematicians noted the different American and Soviet definitions of strategic
48 stability, but defined it themselves as the absence of the capability on either side to
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55 ⁴⁷ Lieber and Press.

56 ⁴⁸ Trachtenberg, p. 210. Trachtenberg also notes that the implications of this were never realized in
57 arms control agreements, a gap which continues to exist.

58 ⁴⁹ Miles.

59 ⁵⁰ Gallagher.

60 ⁵¹ Brustlein, p. 45.

serve a disarming blow to the other.⁵² Parity was preferable to superiority, 'when both sides declare that they are guided by the objective of strengthening strategic stability, this reasonably rules out the aim of reaching strategic superiority as an outcome of such a process.'⁵³ When directly applied to arms control scenarios, therefore, mathematical models similarly tend to focus on technical factors. Other models, however, such as TIT FOR TAT, which have been applied to arms control, demonstrated the value of reciprocity in promoting stability and moves which are not necessarily quantitative or technical, but rather are 'nice' garner more cooperation and prevent competition.⁵⁴ Applied to international security, this entails a degree of self-restraint that seemingly challenges a self-help system.

But strategic stability is also a mathematical concept independent of its application to nuclear balancing and deterrence. In much of the mathematics literature, strategic stability is associated with equilibrium, such as the Nash Equilibrium, wherein another player's perception is an important variable in assessing stability.⁵⁵ Kolber and Mertens define equilibrium and stability in terms of cooperation – 'no player can increase his payoff by unilaterally changing his strategy' and stability in a game is one in which 'no player will ever have an incentive to deviate from his prescribed strategy', as determined with the other player in pre-play communication.⁵⁶ In a 2001 study, Baliga and Sjostrom applied the Nash Equilibrium to arms races and found stability largely depended on a player's type, which was informed by 'private information.'⁵⁷

Ecology is a wholly different field that uses the concept of strategic stability to describe a balance in nature, defined as, 'the ability of a system to return to an

⁵² V.A. Gelovani, A. A. Piontkovsky, and A.P. Skerokhodov, 'Strategic Stability Analysis through Mathematical Modeling', *International Political Science Review*, 11/2 (Apr., 1990), p. 244.

⁵³ Ibid,

⁵⁴ See, for example, Andrew H. Kydd, *Trust and Mistrust in International Relations* (Princeton: Princeton University Press, 2006), which uses a Bayesian model to demonstrate how states can build trust in arms control over time through a series of games.

⁵⁵ Sandeep Baliga and Tomas Sjöström, 'Arms Races and Negotiations', *Review of Economic Studies*, 71 (2004), p. 352.

⁵⁶ Elon Kohlberg and Jean-Francois Mertens, 'On the Strategic Stability of Equilibria', *Econometrica*, 54:5 (Sept., 1986), p. 1004.

⁵⁷ Baliga and Sjöström, p. 352.

equilibrium state after a temporary disturbance.’⁵⁸ Similar to mathematics, stability is closely tied to the concept of equilibrium. Historical notions of stability in ecosystems existed when, ‘no changes could be detected in the identities or population sizes of the component species of a biotic community.’⁵⁹ Around the turn of the 20th century, however, this approach shifted to a more ‘dynamic’ concept that emphasized ‘dynamic balance’ and ‘persistence.’ One expert, Orians, provided a useful framework of seven ways in which ecologists conceptualize stability:

- (1) Constancy- the lack of change in some parameter;
- (2) Persistence- the survival time of a system or some component of it;
- (3) Inertia- the ability of a system to resist external perturbations;
- (4) Elasticity- the speed with which the system returns to its former state;
- (5) Amplitude- the area over which a system is stable;
- (6) Cyclic stability- the ability of a system to cycle or oscillate around some central point or zone;
- (7) Trajectory stability- the ability of a system to move towards some final end point or zone despite differences in starting points.⁶⁰

This multidisciplinary approach highlights two traits to inform a new definition of strategic stability- equilibrium and equanimity- that can be applied to the study of strategic stability in international security. First, strategic stability entails equilibrium, a balance wherein no state has an incentive to use nuclear weapons first because of the other side’s ability to retaliate.⁶¹ Once underlying political tensions are addressed, arms control becomes a means of signalling political agreement and ‘self-propels’ states to avoid military competition and instead seek out cooperation.⁶² Second, strategic stability is also characterized by equanimity, or the ability of states to avoid escalation and return to a state of equilibrium despite perturbations in the international system, such as the emergence of new technologies, threats, crises, or conflicts.⁶³

⁵⁸ C.S. Holling, ‘Resilience and Stability of Ecological System’, *Annual Review of Ecology and Systematics*, 4 (1973), p. 17. I am extremely grateful to Robert Downes for directing me to the ecology literature on this topic.

⁵⁹ E.D. McCoy and Kristin Shrader-Frechette, ‘Community Ecology, Scale, and the Instability of the Stability Concept’, *PSA: Proceeding of the Biennial Meeting of the Philosophy of Science Association*, 1 (1992), p. 184.

⁶⁰ As described and analysed in McCoy, pp. 186-187.

⁶¹ See, also, Miles for a useful discussion on equilibrium in strategic stability.

⁶² Trachtenberg, p. 204.

⁶³ Miles, p. 424.

Cold War theorists inherently recognized the need for states to respond to geopolitical shifts with caution, such as Schelling and Halperin’s observation that a system is, “stable” when political events, internal and external to the countries involved, technological change, accidents, false alarms, misunderstandings, crises, limited wars, or changes in the intelligence available to both sides, are unlikely to disturb the incentives sufficiently to make mutual deterrence fail.’⁶⁴ In a recent study on the concept of strategic stability, Miles similarly concludes, ‘True stability would go further by providing mutual restoring forces to drive adversaries to back down- to deescalate a crisis, or to revise their aims, or to stop expanding their arsenals, or even to reverse an arms buildup.’⁶⁵

This multidisciplinary approach highlights the complexity around strategic stability. Indeed, hypersonic technology may not necessarily be as destabilising as its critics suggest, if possessors, policymakers, and analysts can adopt a more dynamic approach to stability. A more nuanced and sanguine approach to strategic stability may indeed challenge the general pessimism about emerging technologies as suggested by the introduction to this special issue, whereby ‘the fear that emerging technologies will necessarily cause sudden and spectacular changes to international politics should be treated with caution’ - few technologies fundamentally change conflict dynamics, and the effects of technology are ‘variegated.’⁶⁶

What does this mean for arms control? Given that strategic stability is in the eye of the beholder and asymmetry is increasingly a trend in international conflict, particularly across domains, arms control can respond by adopting the principles of dynamism, equilibrium, and equanimity in order to remain a tool for strengthening strategic stability.

Asymmetric Arms Control Framework

Asymmetry in arms control can take many forms, and any discussion into asymmetric options for incorporating emerging technology is at risk of getting muddled without a

⁶⁴ Schelling and Halperin, p. 50.
⁶⁵ Miles, p. 430.
⁶⁶ Todd Sechser, Neil Narang, and Caitlin Talmadge, “Emerging Technologies and Strategic Stability in Peacetime, Crisis, and War,” *Journal of Strategic Studies* (2019).

more rigorous and structured approach. To address this challenge, the following framework examines opportunities for asymmetries in reductions, asymmetries in ceilings, and asymmetry across domains within arms control agreements. To demonstrate the utility of the typology in exploring opportunities for arms control and emerging technology, the discussion includes scenarios for HGV arms control. The framework and scenarios are evaluated in the conclusion. It is worthwhile to observe at the outset that asymmetry is not a wholly new practice in arms control, nor the notion of flexibility in ceilings, as evidenced by the historical examples offered here.⁶⁷ What this framework hopes to do, therefore, is offer a more systematic approach to asymmetric arms control in the hopes that it opens intellectual space and policy opportunities to manage risks associated with emerging technologies

Asymmetry of reductions

Under an asymmetry of reductions, states agree to an equal ceiling on capabilities, such as ICBMs or aircraft; however, one state is required to make more significant reductions than the other to reach those limits. To use a social example, if we both agree to limit ourselves to five cups of coffee per week, but I am regularly drinking ten glasses whereas you drink six, we feel the effects of this agreement asymmetrically (I will cut five cups per week whereas you must abstain from only one). Drawing on an example from arms control, the 2010 New START Treaty limited the United States and Russia to a shared ceiling of 1550 operationally-deployed strategic warheads, 700 delivery vehicles, and 800 launchers. But the countries' arsenals were not quantitative (or qualitative) equivalents at the time negotiations concluded in 2010, therefore this ceiling created an imbalance in reduction requirements. Table 1, American and Russian Reductions Under New START, 2011-2018, shows cuts by both countries across delivery vehicles, warheads, and launchers based on initial and final data exchanges under the treaty.

	United States	Russia
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⁶⁷ I am particularly grateful to the anonymous reviewer for highlighting this point as part of the historical legacy of arms control. Examples include Graham T. Allison and Frederin A. Morris, 'Armaments and Arms Control', *Daedalus*, 104:3 (Summer, 1975); Richard K. Betts, 'Systems for Peace or Causes for War? Collective Security, Arms Control, and the New Europe', *International Security*, 17:1 (Summer, 1992), pp. 5-43; and policy recommendations by contemporary experts including James Acton and Steven Pifer.

Delivery vehicles	-230 (882:652)	+6 (521:527)
Warheads	-450 (1800:1350)	-93 (1537:1444)
Launchers	-324 (1124:800)	-86 (865:779)

Table 1: American and Russian Reductions Under New START, 2011-2018⁶⁸

Table 1 demonstrates that New START was an asymmetry in reductions, wherein the United States had to cut 450 warheads, for example, compared to Russia only cutting 93. Even more stark, Russia actually built up its delivery vehicles in real numbers, and was also building up its warhead numbers in the later stages of the treaty, although it ultimately settled at a net decrease.⁶⁹ Albeit not reflected in the reductions or the treaty itself, this asymmetry was acceptable because of Russia’s significant numerical superiority in tactical nuclear weapons (TNW), meaning that Russia still maintained more aggregate nuclear weapons. An asymmetry in reductions could implicitly take into account redundant systems or other factors, such as TNW, missile defense, or advanced conventional weapons.

Scenario 1: Bilateral reductions

Asymmetry of reductions is difficult to conceptualize given that HGVs are still in the development phase, therefore there is nothing to reduce at present. Nonetheless, we can envision a scenario following a U.S.-Russia HGV arms race, in which they agree to reduce to an agreed upon limit, hypothetically 100 vehicles each. Ostensibly, one side would have been further along in its development and its HGV technology may have a qualitative advantage. Therefore, while Washington and Moscow agree to limit themselves to the same number, one makes a smaller cut or is quantitatively better-off.

Asymmetry of ceilings

A second type of asymmetry is in ceilings, whereby states agree to unequal limits. A classic nuclear example of this is the SALT Interim Agreement, an important case study of attempts to incorporate emerging technology into arms control, namely

⁶⁸ U.S. Department of State, ‘New START Fact Sheets’, June 1, 2011 and February 22, 2018, available at: <https://2009-2017.state.gov/t/avc/rls/164722.htm> and <https://www.state.gov/t/avc/newstart/278775.htm>.

⁶⁹ Hans M. Kristensen, ‘New START Data Shows Russian Warhead Increase Before Expected Decrease’, *Federation of American Scientists*, October 3, 2016.

multiple independently-targetable re-entry vehicles (MIRV) and missile defenses. SALT is a case of quantitative asymmetry, whereby the United States and Soviet Union limited similar capabilities but at different levels, as demonstrated in Table 2, American and Soviet Ceilings Under SALT.

	United States	Soviet Union
ICBM silos	1,054	1,607
SLBM launch tubes	710	950
Submarines	44	62

Table 2: American and Soviet Ceilings Under SALT

The SALT Interim Agreement did not require reductions but rather capped existing capabilities, allowing for a small cushion to account for launch tubes and submarines under construction to replace existing systems. At the outset, the SALT Interim Agreement's stated goals were to, 'contribute to the creation of more favourable conditions for active negotiation on limiting strategic arms as well as to the relaxation of international tensions and the strengthening of trust between States....'⁷⁰ This practical approach accounted for ongoing competition in the strategic domain but sought to limit the potentially negative impact of emerging technologies on strategic stability.

Asymmetry of ceilings- Scenario 2: Quantitative imbalance

In this scenario, the United States and Russia would sign a treaty limiting their HGVs but at different levels. Ceilings would be agreed to depending on respective stages of development in HGV technology, along with plans for HGV deployment in relation to nuclear weapons. For example, given Russia's numerical advantage of TNW and development of dual-capable cruise missiles, the United States might be allowed slightly higher number of HGVs, or they could adopt a ratio, such as 5:4, based on a variety of criteria (e.g. warhead numbers, strategic delivery vehicles, launchers, and missile defense). Given that neither side has stated how many HGVs they plan to develop or for what purpose, it is impossible to propose even hypothetical ceilings.

⁷⁰ *Interim Agreement between the United States of America and the Union of Soviet Socialist Republics on Certain Measures with Respect to the Limitation of Strategic Offensive Arms (SALT I)*, 1972, available at: <http://www.nti.org/media/pdfs/aptsaltI.pdf>.

Such an exchange would largely depend on HGV ranges, technology, and any progress in HGV defense.

Asymmetry of ceilings- Scenario 3: Hypersonic ‘haves’ and ‘have-nots’

This scenario would use the model of the NPT in which a multilateral agreement permitted the United States, Russia, and China to continue to develop and deploy HGVs to an agreed limit, and all other states would agree to refrain from doing so. Essentially, it would create hypersonic ‘haves’ and ‘have-nots’. There would be no verification, but all states parties would agree to various confidence-building measures (CBMs), such as regular consultations and meetings about the risks associated with HGVs. This might be thought of as similar to the 1925 Geneva Protocol, but with three states having exceptional status.

Asymmetry of domains

And finally, asymmetry of domains would see states reciprocate reductions but of dissimilar capabilities. Essentially these are non-like-for-like exchanges and designed to address the challenges of asymmetry and emerging technology. Historical examples of asymmetric exchanges across domains to include nuclear weapons are relatively limited, with the exception of an option explored amidst negotiation of the INF Treaty that was ultimately abandoned. At the time the Soviet Union maintained a significant conventional advantage, whereby the realization of nuclear reductions and the INF Treaty would leave a strategic imbalance favoring Moscow. To address this, Gorbachev floated the idea of unilateral Soviet conventional cuts or asymmetric conventional exchanges, which also would have shifted resources to his economic priorities. In a study on this idea of asymmetric arms control in 1988, Jack Snyder concluded, ‘conventional arms control could contribute to NATO’s security by redressing the small imbalance favouring the (Warsaw) Pact at the outset of mobilization, and possibility also the somewhat larger imbalance when reinforcements from the Western USSR arrive.’⁷¹ Snyder offered three scenarios for arms control, including ‘armor-for-armor, airpower-for-airpower, or airpower-for armor trades’, along with the suggestion that the United States exchange limits on the Strategic Defense Initiative, which might induce the Soviets to, ‘make highly

⁷¹ Jack Snyder, ‘Limiting Offensive Conventional Forces: Soviet Proposals and Western Options’, *International Security*, 12:4 (1988), pp. 65-66.

asymmetric conventional cuts, making NATO's problem easier to solve.'⁷²

Ultimately, the Soviet Union made unilateral cuts under Gorbachev in 1988 and asymmetric cuts were never formally negotiated.

A final historical example of asymmetry of domains is the arms control process that accompanied the Dayton peace accords, the Agreement on Sub-Regional Arms Control which placed limits on five types of weapons across two domains (land and air) for three principle countries, one of which included two subsidiary groups. The Sub-Regional Agreement recognized, 'arms control is essential to creating a stable peace in the region.'⁷³ Table 3, Actual and Allowed Armaments Under the Sub-Regional Arms Control Agreement, compares reductions (and buildups) across domains and weapon types as part of the post-conflict peace process.

	Federal Republic of Yugoslavia	Croatia	Bosnia-Herzegovina (Federation)	Bosnia-Herzegovina (Srpska)
Tanks	1300/1025	400/410	135/273	330/137
Armored Combat Vehicles	1000/850	300/340	80/227	400/113
Artillery	4000/3750	1700/1500	1500/1000	1600/500
Combat Aircraft	280/155	20/62	0/41	40/21
Helicopters	110/53	30/21	12/14	30/7

Table 3: Actual/Allowed Armaments under the Sub-Regional Arms Control Agreement⁷⁴

Table 3 shows that the Sub-Regional Agreement included asymmetry on multiple levels, including reductions, ceilings, and domains. For example, while the Bosnia-Herzegovina Federation was permitted to build *up* its number of combat aircraft from zero to 41, the Bosnia-Herzegovina Republic of Srpska was required to reduce from

⁷² iBid., p. 50.

⁷³ 'Measure for Sub-Regional Arms Control', available at: <https://www.state.gov/eur/rls/or/dayton/52579.htm>.

⁷⁴ Compiled from McCaulsland; Michael O'Hanlon, 'Arms control and military stability in the Balkans', *Arms Control Today*, 26:6 (1996); and Organization for Security and Co-operation in Europe Mission to Bosnia and Herzegovina, 'Agreement on Sub-regional Arms Control: Article IV', 15 June 1996, available at: <https://web.archive.org/web/20110721101240/http://arhiva.morh.hr/hvs/SPORAZUMI/tekstovi/SSKN-engleski.pdf>. Additionally, allotments for the Bosnia-Herzegovina Federation were further divided between Bosnian Muslims and Bosnian Croats, see O'Hanlon.

40 to 21.⁷⁵ The agreement was initially based on a 5:2:2 ratio, ‘basing allotments of weapons primarily on relative populations’, and entailed CBMs, such as the right to observe large-scale exercises and inspection of 10-20% of treaty limited items.⁷⁶

Admittedly, there are challenges with comparing arms control in small arms and a regional post-conflict scenario to the challenges of limiting competition in U.S.-Russia-China advanced conventional weapons. Following the Dayton Accords, states parties had powerful patrons that were committed to training and re-equipping their client states, which had the potential to undermine the peace process and violate the agreements.⁷⁷ These patrons served an important role as a backstop to the peace agreement which would be missing in any U.S.-Russia-China HGV grand bargain. Second, the 1996 Sub-Regional Agreement included multiple states and intra-state groups, which complicated negotiations and, according to O’Hanlon, made it hard ‘to know whose arms quota should equal whose’, creating uncertainty about how the agreement would respond to external pressures.⁷⁸ Such challenges would be exacerbated at the global level among the leaders in strategic weapons. And finally, the conventional arms control cases offered here occurred in vastly different geopolitical contexts than the current climate. In the case of New START, SALT, and INF, the United States and Soviet Union were experiencing an era of rapprochement and the asymmetric options were part of a package of other arms control discussions. All the scenarios offered here face limitations, but they also offer a creative approach to adapt arms control to emerging technologies and strategic stability that includes nuclear and non-nuclear components.

Asymmetry of domains- Scenario 4: Cross-domain CBMs

Under the terms of scenario 4, the United States, Russia, and China, would agree to a series of CBM dialogues on HGVs and how these would be incorporated into existing strategic forces and planning. It would include reciprocal transparency measures, such as demonstrations and military-to-military dialogues. The three states would not agree to any limits on HGVs, but rather would cooperate specifically in discussing HGVs as

⁷⁵ O’Hanlon.

⁷⁶ iBid.

⁷⁷ McCaulsand, p. 23.

⁷⁸ O’Hanlon, p. 6.

they relate to other domains, particularly nuclear. This scenario would also include a joint declaration not to use HGVs to target each other's nuclear forces.

Asymmetry of domains- Scenario 5: Bilateral ratios

Scenario 5 is a more ambitious approach to U.S.-Russia strategic arms control, building on lessons learned from a wide variety of historical examples but in the same trend of START and New START to include a high level of technical detail, inspections, and recognition of offense-defense balance. It would entail a legally-binding agreement to the following:

- A 10:1 ratio of *all* existing nuclear delivery vehicles (intercontinental ballistic missiles, submarine-launched ballistic missiles, bombers, cruise missiles, and shorter-range aircraft) to include HGVs.
- Of the HGVs allowed, only 25% could be nuclear-capable.
- HGVs cannot be co-located with nuclear delivery systems.
- On-site verification, data exchange, and a consultative committee.
- Declaratory statement that HGVs will never be used to target nuclear forces.

Asymmetry of domains- Scenario 6: Two-Stage Limitations

In the final scenario, the United States and Russia would agree to an overall limit of 1000 nuclear warheads on 600 delivery vehicles, to include HGVs, TNW, and strategic delivery vehicles. A similar format was adopted for New START itself, whereby conventionally-armed ballistic missiles are counted under the treaty and cannot exceed 700 in total, along with their warheads which fall under the 1550 ceiling.⁷⁹ This applies to conventional weapons with a ballistic trajectory for the majority of its flight time, however Russia, interestingly, did not ask for similar restraints on conventional boost-glide weapons.⁸⁰

Under this scenario, reductions would take place over two phases. In the first phase, both sides would start the process of reducing their nuclear forces to reach the agreed limits by a set date. In the second phase, when HGVs are fully developed and deployed, the United States and Russia would make further reductions to their nuclear

⁷⁹ Amy Woolf, 'Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues', *Congressional Research Service*, 2017.

⁸⁰ James M. Acton, 'Russia and Strategic Conventional Weapons', *Nonproliferation Review*, 22/2 (2015), pp. 141-154.

forces so as to compensate for the additional HGVs into their ceiling limits, but these reductions in nuclear forces would be asymmetric depending on force posture and decisions about how many HGVs to deploy and allow for flexibility on both sides. Unlike New START, however, China would join the agreement at a 5:1 ratio in both nuclear warheads and strategic delivery vehicles to the United States and Russia to account for the current imbalance in strategic forces.

Conclusion: Arms Control Dynamism

The goal of this final section is to evaluate the asymmetric arms control framework, the scenarios for HGV asymmetric arms control, and to identify scope for further research. At least four trends emerge from the application of the asymmetric arms control framework to HGVs. First, HGVs are a trilateral issue. In the bilateral scenarios discussed here, such as scenarios 1 and 5, China may see this as an opportunity to gain a strategic advantage and build up its HGV arsenal. This, in turn, jeopardizes the sustainability of any agreement whereby both Washington and Moscow may become increasingly uneasy with this imbalance outside of the treaty for fear of an ‘HGV gap’. This correlates to the new challenge to strategic stability presented by asymmetries and emerging technologies; indeed, arms control is no longer a purely strategic *bilateral* dynamic.

Second, arms control does not happen in a political vacuum. Rather it is a manifestation of political processes and changes, albeit states have some ability to shape those processes. Any scenario that entails an asymmetry in ceilings is politically unfeasible at present, whereby one side would be required to accept a lower number, which would exacerbate fears of vulnerability and increase incentives for pre-emptive first strikes. Jacquelyn Schneider has demonstrated how emerging technologies can exacerbate these perceptions of vulnerability in the capability/vulnerability paradox, whereby the revolution in military technology creates ‘novel vulnerabilities’ that could increase incentives for first strike.⁸¹ This aspect of emerging technology adds an additional level of complexity for efforts to apply arms control.

⁸¹ Jacquelyn Schneider, ‘The Capability/Vulnerability Paradox and Military Revolutions: Implications for Computing, Cyber, and the Onset of War,’ *Journal of Strategic Studies* (2019).

Numerical imbalances also present domestic political challenges. In cases of asymmetry in ceilings, any agreement permitting Russia a higher number of capabilities relative to the United States would not be palatable to Congress or to the national security stakeholders committed to, 'the task to ensure that American military superiority endures....'⁸² Additionally, while scenario 5 crosses domains and offers transparency and predictability, renegotiating the details of such an agreement would be politically and technically onerous. Arms control is also influenced by external political factors and the broader geopolitical context. Many of the scenarios here could be unfavorably perceived by U.S. allies as a signal of waning commitment to it deterrence and assurance missions. Scenario 3, in particular, would be politically unfeasible given the enduring controversy around the two-tiered system of the NPT and other states would be reluctant to join a similarly-structured agreement in which all states are not treated as equals. Scenario 3, with 'haves' and 'have-nots', would not limit the arms race between the United States, Russia, and China, nor would it reduce the risks of misperception in a crisis absent more robust transparency measures and reciprocal limits.

Perhaps the most important theme from the asymmetric arms control framework is to incorporate dynamism, an important concept in the multidisciplinary literature on strategic stability, to account for changes in the environment. Dynamism can be practiced in arms control by allowing for flexibility in force posturing and the treaty itself, 'to allow consensual changes in the obligations imposed in order to fulfill the object of the treaty in uncertain conditions. Dynamic obligations arise under agreements that allow the parties to mutually adjust commitments while maintaining a shared perception of reciprocal responsibility.'⁸³ Applied to emerging technologies, dynamism in arms control can focus on managing rather than stopping the arms race, allowing for the political realities that inspire competition in military capabilities but preventing its destabilizing effects. This was an important component of SALT, for example, and in scenarios 1, 5, and 6 above by allowing a cushion in numerical limits for systems currently under construction.

⁸² U.S. National Security Strategy, 2017, p. 3.

⁸³ Edwin Smith, 'Understanding Dynamic Obligations: Arms Control Agreements', *Southern California Law Review*, 64 (1991), p. 1557.

There may also be prospects for flexibility and dynamism in the formality of treaties. A current debate in arms control literature is whether or not it must be legally-binding or could be more informal agreements. Sarah Kreps, for example, has observed:

International negotiators might be better served drafting less highly legalized agreements that offer latitude in states' commitment to the agreement, since the prospect of tying their hands will discourage states from engaging in higher-obligation commitments. Backing away from aggressive delegation measures might also help states buy into an agreement, a dynamic illustrated by experiences of Cold War arms control negotiations in which the Soviets in particular were leery of the intrusiveness of on-site inspections.⁸⁴

Conversely, O'Connell's historical analysis argues that the legal nature of treaties offers the most benefit for international security with predictability in an era of uncertainty.⁸⁵ Is cross-domain arms control, to include asymmetries, better served by informal and flexible agreements, or does it necessitate legally-binding treaties with verification?

Potential criticisms of the framework resonate with historical arguments that arms control did not do what it promised⁸⁶, favored the superpowers at the expense of all other states⁸⁷, and offering limited tangible gains aside from economic savings.⁸⁸ And more recently, Gallagher arraigned technical or quantitative approaches to strategic stability, which could also apply to these options for arms control:

[A] predominantly technical way to make deterrence more stable by changing force structure characteristics, military operations, relative numbers of weapons on either side, or total number of nuclear weapons gives short shrift to political factors, including the fundamental assumptions about world politics that inform different arms control logics, the quality of political relations among leading states, and the political processes that affect negotiation, ratification, and implementation.⁸⁹

Many criticisms of arms control, however, fail to acknowledge its inter-relationship with international security more broadly and treat it as a false binary of either technical/quantitative or political/qualitative. The asymmetric options here are meant

⁸⁴ Kreps, p. 18.

⁸⁵ O'Connell.

⁸⁶ Colin S. Gray, 'Arms Control Does Not Control Arms', *Orbis*, 37/3 (1993), pp. 333-348.

⁸⁷ Hedley Bull, 'Arms Control and World Order', *International Security*, 1/1 (1976), pp. 3-16.

⁸⁸ Bernard Brodie, 'On the Objectives of Arms Control', *International Security*, 1/1 (1976), p. 19.

⁸⁹ Gallagher, p. 469.

to capture both quantitative and qualitative factors, and provide various options depending on political conditions and technological developments. Implementing the principles of dynamism, of the scenarios highlighted by this framework, the most useful approach may be a combination of Scenario 4 CBMs leading to Scenario 6, two-stage limitations.

Ultimately states engage in arms control when it is in the national interest. At present, technical and political hurdles limit options for incorporating emerging technologies into arms control; however, expanding the objectives of strategic stability and arms control opens creative approaches for addressing asymmetries in capabilities and domains. This challenges the conventional wisdom that strategic stability and arms control are out-dated Cold War practices. Indeed, history demonstrates that opportunities for arms control often arise unexpectedly and creative visions that cross domains and combine informal approaches with multi-stage agreements can lay the groundwork for when political conditions become more favourable for cooperation.

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